

# GTL2003

## 8-bit bidirectional low voltage translator

Rev. 01 — 27 July 2007

Product data sheet

### 1. General description

The Gunning Transceiver Logic - Transceiver Voltage Clamps (GTL-TVC) provide high-speed voltage translation with low ON-state resistance and minimal propagation delay. The GTL2003 provides 8 NMOS pass transistors (Sn and Dn) with a common gate (GREF) and a reference transistor (SREF and DREF). The device allows bidirectional voltage translations between 1.0 V and 5.0 V without use of a direction pin.

When the Sn or Dn port is LOW, the clamp is in the ON-state and a low resistance connection exists between the Sn and Dn ports. Assuming the higher voltage is on the Dn port, when the Dn port is HIGH, the voltage on the Sn port is limited to the voltage set by the reference transistor (SREF). When the Sn port is HIGH, the Dn port is pulled to  $V_{CC}$  by the pull-up resistors. This functionality allows a seamless translation between higher and lower voltages selected by the user, without the need for directional control.

All transistors have the same electrical characteristics and there is minimal deviation from one output to another in voltage or propagation delay. This is a benefit over discrete transistor voltage translation solutions, since the fabrication of the transistors is symmetrical. Because all transistors in the device are identical, SREF and DREF can be located on any of the other eight matched Sn/Dn transistors, allowing for easier board layout. The translator's transistors provide excellent ESD protection to lower voltage devices and at the same time protect less ESD-resistant devices.

### 2. Features

- 8-bit bidirectional low voltage translator
- Allows voltage level translation between 1.0 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, and 5 V buses which allows direct interface with GTL, GTL+, LVTTTL/TTL and 5 V CMOS levels
- Provides bidirectional voltage translation with no direction pin
- Low  $6.5 \Omega$  ON-state resistance ( $R_{on}$ ) between input and output pins (Sn/Dn)
- Supports hot insertion
- No power supply required: will not latch up
- 5 V tolerant inputs
- Low standby current
- Flow-through pinout for ease of printed-circuit board trace routing
- ESD protection exceeds 2000 V HBM per JESD22-A114, 200 V MM per JESD22-A115, and 1000 V CDM per JESD22-C101
- Packages offered: TSSOP20, DHVQFN20



### 3. Applications

- Any application that requires bidirectional or unidirectional voltage level translation from any voltage from 1.0 V to 5.0 V to any voltage from 1.0 V to 5.0 V
- The open-drain construction with no direction pin is ideal for bidirectional low voltage (for example, 1.0 V, 1.2 V, 1.5 V, or 1.8 V) processor I<sup>2</sup>C-bus port translation to the normal 3.3 V and/or 5.0 V I<sup>2</sup>C-bus signal levels or GTL/GTL+ translation to LVTTTL/TTL signal levels.

### 4. Ordering information

**Table 1. Ordering information**

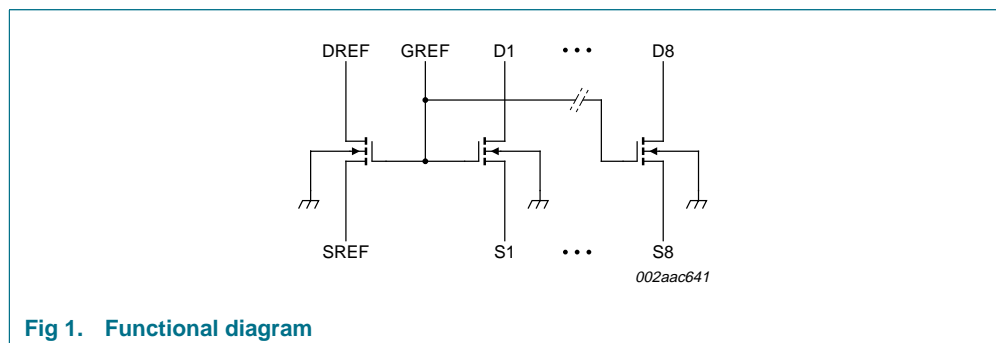
| Type number | Package  |  | Version  |
|-------------|----------|--|----------|
|             | Name     | Description  |          |
| GTL2003BQ   | DHVQFN20 | plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 20 terminals; body 2.5 × 4.5 × 0.85 mm | SOT764-1 |
| GTL2003PW   | TSSOP20  | plastic thin shrink small outline package; 20 leads; body width 4.4 mm   | SOT360-1 |

#### 4.1 Ordering options

**Table 2. Ordering options**

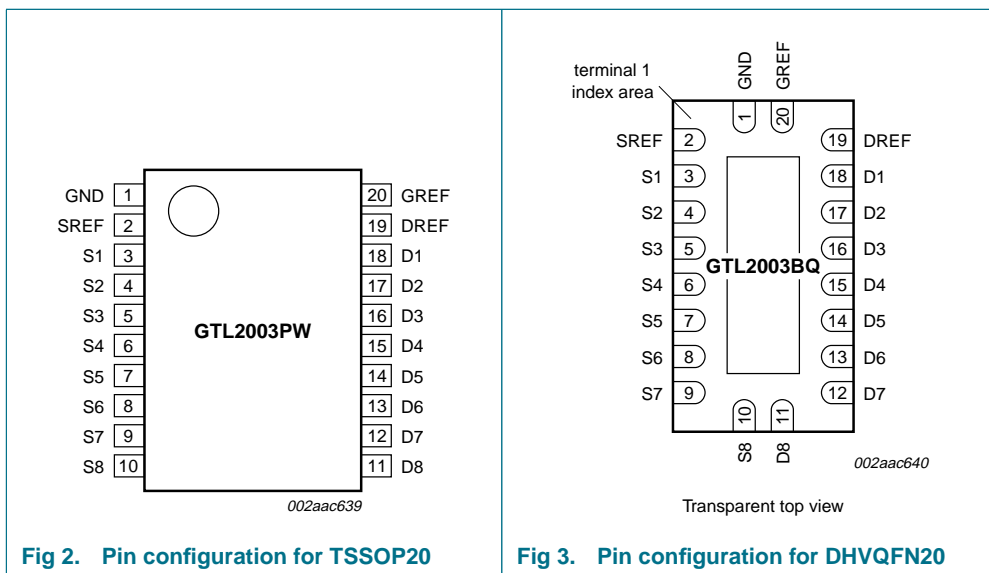
| Type number | Topside mark | Temperature range |
|-------------|--------------|-------------------|
| GTL2003BQ   | 2003         | -40 °C to +85 °C  |
| GTL2003PW   | GTL2003      | -40 °C to +85 °C  |

### 5. Functional diagram



## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

Table 3. Pin description

| Symbol   | Pin                            | Description                    |
|----------|--------------------------------|--------------------------------|
| GND      | 1 <sup>[1]</sup>               | ground (0 V)                   |
| SREF     | 2                              | source of reference transistor |
| S1 to S8 | 3, 4, 5, 6, 7, 8, 9, 10        | Port S1 to Port S8             |
| D1 to D8 | 18, 17, 16, 15, 14, 13, 12, 11 | Port D1 to Port D8             |
| DREF     | 19                             | drain of reference transistor  |
| GREF     | 20                             | gate of reference transistor   |

[1] DHVQFN package die supply ground is connected to both GND pin and exposed center pad. GND pin must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board level performance, the exposed pad needs to be soldered to the board using a corresponding thermal pad on the board and for proper heat conduction through the board, thermal vias need to be incorporated in the printed-circuit board in the thermal pad region.

## 7. Functional description

Refer also to [Figure 1 “Functional diagram”](#).

### 7.1 Function selection

**Table 4. Function selection, HIGH-to-LOW translation**

Assumes Dn is at the higher voltage level.

H = HIGH voltage level; L = LOW voltage level; X = Don't care

| GREF <sup>[1]</sup> | DREF | SREF                              | Input Dn | Output Sn               | Transistor |
|---------------------|------|-----------------------------------|----------|-------------------------|------------|
| H                   | H    | 0 V                               | X        | X                       | off        |
| H                   | H    | $V_T$ <sup>[2]</sup>              | H        | $V_T$ <sup>[2][3]</sup> | on         |
| H                   | H    | $V_T$ <sup>[2]</sup>              | L        | L <sup>[4]</sup>        | on         |
| L                   | L    | $0\text{ V} - V_T$ <sup>[2]</sup> | X        | X                       | off        |

[1] GREF should be at least 1.5 V higher than SREF for best translator operation.

[2]  $V_T$  is equal to the SREF voltage.

[3] Sn is not pulled up or pulled down.

[4] Sn follows the Dn input LOW.

**Table 5. Function selection, LOW-to-HIGH translation**

Assumes Dn is at the higher voltage level.

H = HIGH voltage level; L = LOW voltage level; X = Don't care

| GREF <sup>[1]</sup> | DREF | SREF                              | Input Sn             | Output Dn        | Transistor |
|---------------------|------|-----------------------------------|----------------------|------------------|------------|
| H                   | H    | 0 V                               | X                    | X                | off        |
| H                   | H    | $V_T$ <sup>[2]</sup>              | $V_T$ <sup>[2]</sup> | H <sup>[3]</sup> | nearly off |
| H                   | H    | $V_T$ <sup>[2]</sup>              | L                    | L <sup>[4]</sup> | on         |
| L                   | L    | $0\text{ V} - V_T$ <sup>[2]</sup> | X                    | X                | off        |

[1] GREF should be at least 1.5 V higher than SREF for best translator operation.

[2]  $V_T$  is equal to the SREF voltage.

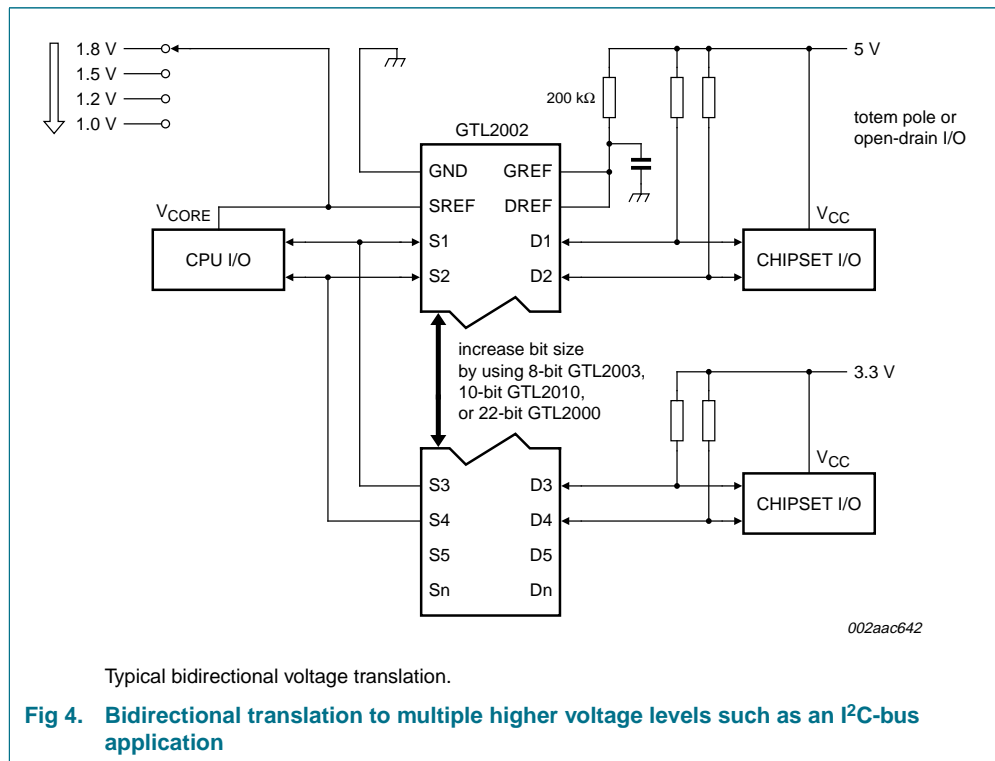
[3] Dn is pulled up to  $V_{CC}$  through an external resistor.

[4] Dn follows the Sn input LOW.

## 8. Application design-in information

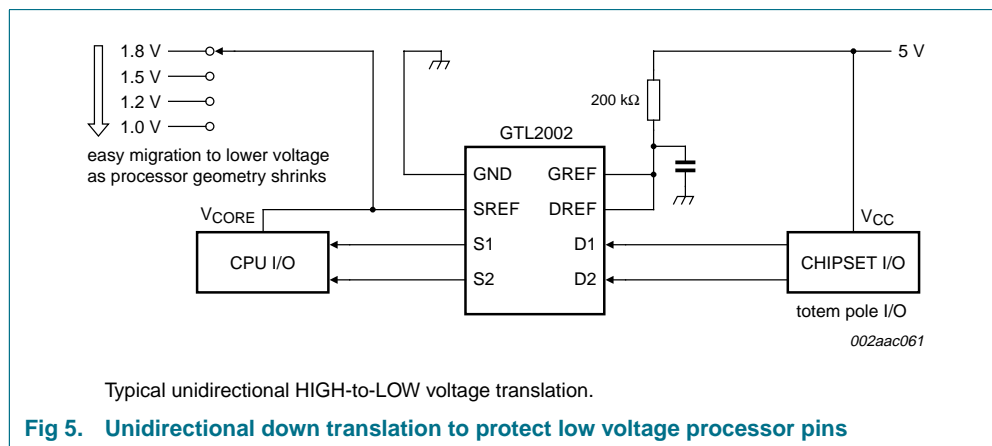
### 8.1 Bidirectional translation

For the bidirectional clamping configuration, higher voltage to lower voltage or lower voltage to higher voltage, the GREF input must be connected to DREF and both pins pulled to HIGH side  $V_{CC}$  through a pull-up resistor (typically 200 k $\Omega$ ). A filter capacitor on DREF is recommended. The processor output can be totem pole or open-drain (pull-up resistors may be required) and the chip set output can be totem pole or open-drain (pull-up resistors are required to pull the Dn outputs to  $V_{CC}$ ). However, if either output is totem pole, data must be unidirectional or the outputs must be 3-stateable and the outputs must be controlled by some direction control mechanism to prevent HIGH-to-LOW contentions in either direction. If both outputs are open-drain, no direction control is needed. The opposite side of the reference transistor (SREF) is connected to the processor core power supply voltage. When DREF is connected through a 200 k $\Omega$  resistor to a 3.3 V to 5.5 V  $V_{CC}$  supply and SREF is set between 1.0 V to ( $V_{CC} - 1.5$  V), the output of each Sn has a maximum output voltage equal to SREF and the output of each Dn has a maximum output voltage equal to  $V_{CC}$ .



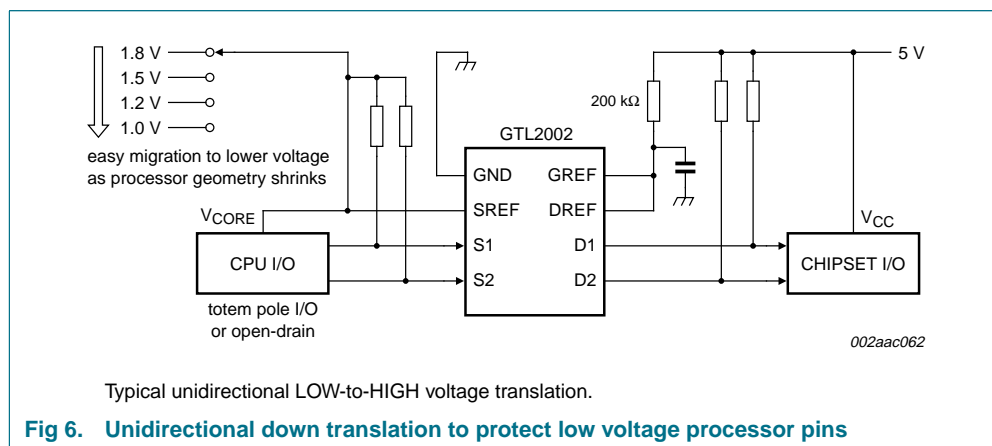
### 8.2 Unidirectional down translation

For unidirectional clamping, higher voltage to lower voltage, the GREF input must be connected to DREF and both pins pulled to the higher side  $V_{CC}$  through a pull-up resistor (typically 200 k $\Omega$ ). A filter capacitor on DREF is recommended. Pull-up resistors are required if the chip set I/O are open-drain. The opposite side of the reference transistor (SREF) is connected to the processor core supply voltage. When DREF is connected through a 200 k $\Omega$  resistor to a 3.3 V to 5.5 V  $V_{CC}$  supply and SREF is set between 1.0 V to ( $V_{CC} - 1.5$  V), the output of each  $S_n$  has a maximum output voltage equal to SREF.



### 8.3 Unidirectional up translation

For unidirectional up translation, lower voltage to higher voltage, the reference transistor is connected the same as for a down translation. A pull-up resistor is required on the higher voltage side (Dn or Sn) to get the full HIGH level, since the GTL-TVC device will only pass the reference source (SREF) voltage as a HIGH when doing an up translation. The driver on the lower voltage side only needs pull-up resistors if it is open-drain.



## 8.4 Sizing pull-up resistor

The pull-up resistor value needs to limit the current through the pass transistor when it is in the 'on' state to about 15 mA. This will guarantee a pass voltage of 260 mV to 350 mV. If the current through the pass transistor is higher than 15 mA, the pass voltage will also be higher in the 'on' state. To set the current through each pass transistor at 15 mA, the pull-up resistor value is calculated as follows:

$$\text{resistor value } (\Omega) = \frac{\text{pull-up voltage (V)} - 0.35 \text{ V}}{0.015 \text{ A}}$$

[Table 6](#) summarizes resistor values for various reference voltages and currents at 15 mA and also at 10 mA and 3 mA. The resistor value shown in the +10 % column or a larger value should be used to ensure that the pass voltage of the transistor would be 350 mV or less. The external driver must be able to sink the total current from the resistors on both sides of the GTL-TVC device at 0.175 V, although the 15 mA only applies to current flowing through the GTL-TVC device. See application note *AN10145 Bidirectional low voltage translators* for more information.

**Table 6. Pull-up resistor values**

Calculated for  $V_{OL} = 0.35 \text{ V}$ . Assumes output driver  $V_{OL} = 0.175 \text{ V}$  at stated current.

| Voltage | Pull-up resistor value ( $\Omega$ ) |                       |         |                       |         |                       |
|---------|-------------------------------------|-----------------------|---------|-----------------------|---------|-----------------------|
|         | 15 mA                               |                       | 10 mA   |                       | 3 mA    |                       |
|         | Nominal                             | + 10 % <sup>[1]</sup> | Nominal | + 10 % <sup>[1]</sup> | Nominal | + 10 % <sup>[1]</sup> |
| 5.0 V   | 310                                 | 341                   | 465     | 512                   | 1550    | 1705                  |
| 3.3 V   | 197                                 | 217                   | 295     | 325                   | 983     | 1082                  |
| 2.5 V   | 143                                 | 158                   | 215     | 237                   | 717     | 788                   |
| 1.8 V   | 97                                  | 106                   | 145     | 160                   | 483     | 532                   |
| 1.5 V   | 77                                  | 85                    | 115     | 127                   | 383     | 422                   |
| 1.2 V   | 57                                  | 63                    | 85      | 94                    | 283     | 312                   |

[1] + 10 % to compensate for  $V_{DD}$  range and resistor tolerance.

## 9. Limiting values

**Table 7. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).<sup>[1]</sup>

| Symbol            | Parameter              | Conditions                             | Min                 | Max  | Unit |
|-------------------|------------------------|--|---------------------|------|------|
| V <sub>SREF</sub> | voltage on pin SREF    |  | -0.5 <sup>[2]</sup> | +7.0 | V    |
| V <sub>DREF</sub> | voltage on pin DREF    |  | -0.5 <sup>[2]</sup> | +7.0 | V    |
| V <sub>GREF</sub> | voltage on pin GREF    |  | -0.5 <sup>[2]</sup> | +7.0 | V    |
| V <sub>Sn</sub>   | voltage on port Sn     |  | -0.5 <sup>[2]</sup> | +7.0 | V    |
| V <sub>Dn</sub>   | voltage on port Dn     |  | -0.5 <sup>[2]</sup> | +7.0 | V    |
| I <sub>IK</sub>   | input clamping current | SREF, DREF, GREF; V <sub>I</sub> < 0 V | -                   | -50  | mA   |
|                   |                        | port Sn; V <sub>I</sub> < 0 V          | -                   | -50  | mA   |
|                   |                        | port Dn; V <sub>I</sub> < 0 V          | -                   | -50  | mA   |
| I <sub>ch</sub>   | channel current (DC)   | channel in ON-state                    | -                   | ±128 | mA   |
| T <sub>stg</sub>  | storage temperature    |  | -65                 | +150 | °C   |

[1] The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150 °C.

[2] The input and output negative voltage ratings may be exceeded if the input and output clamp current ratings are observed.

## 10. Recommended operating conditions

**Table 8. Recommended operating conditions**

| Symbol                | Parameter                      | Conditions            | Min              | Typ | Max | Unit |
|-----------------------|--------------------------------|-----------------------|------------------|-----|-----|------|
| V <sub>I/O</sub>      | voltage on an input/output pin | Sn, Dn                | 0                | -   | 5.5 | V    |
| V <sub>SREF</sub>     | voltage on pin SREF            |                       | <sup>[1]</sup> 0 | -   | 5.5 | V    |
| V <sub>DREF</sub>     | voltage on pin DREF            |                       | 0                | -   | 5.5 | V    |
| V <sub>GREF</sub>     | voltage on pin GREF            |                       | 0                | -   | 5.5 | V    |
| I <sub>sw(pass)</sub> | pass switch current            |                       | -                | -   | 64  | mA   |
| T <sub>amb</sub>      | ambient temperature            | operating in free-air | -40              | -   | +85 | °C   |

[1] V<sub>SREF</sub> ≤ V<sub>DREF</sub> - 1.5 V for best results in level shifting applications.



## 11. Static characteristics

**Table 9. Static characteristics**

$T_{amb} = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ , unless otherwise specified.

| Symbol  | Parameter                          | Conditions   | Min | Typ <sup>[1]</sup> | Max      | Unit          |          |
|---|------------------------------------|--|-----|--------------------|----------|---------------|----------|
| $V_{OL}$  | LOW-level output voltage           | $V_{DD} = 3.0\text{ V}$ ; $V_{SREF} = 1.365\text{ V}$ ;<br>$V_{Sn}$ or $V_{Dn} = 0.175\text{ V}$ ; $I_{IK} = 15.2\text{ mA}$ | -   | 260                | 350      | mV            |          |
| $V_{IK}$  | input clamping voltage             | $I_I = -18\text{ mA}$ ; $V_{GREF} = 0\text{ V}$  | -   | -                  | -1.2     | V             |          |
| $I_{LI(G)}$   | gate input leakage current         | $V_I = 5\text{ V}$ ; $V_{GREF} = 0\text{ V}$   | -   | -                  | 5        | $\mu\text{A}$ |          |
| $C_{ig}$  | input capacitance at gate          | GREF; $V_I = 3\text{ V}$ or $0\text{ V}$   | -   | 56                 | -        | pF            |          |
| $C_{io(off)}$   | off-state input/output capacitance | $V_O = 3\text{ V}$ or $0\text{ V}$ ; $V_{GREF} = 0\text{ V}$   | -   | 7.4                | -        | pF            |          |
| $C_{io(on)}$  | on-state input/output capacitance  | $V_O = 3\text{ V}$ or $0\text{ V}$ ; $V_{GREF} = 3\text{ V}$   | -   | 18.6               | -        | pF            |          |
| $R_{on}$  | ON-state resistance                | $V_I = 0\text{ V}$ ; $I_O = 64\text{ mA}$  | [2] |                    |          |               |          |
|   |                                    | $V_{GREF} = 4.5\text{ V}$  | -   | 3.5                | 5        | $\Omega$      |          |
|   |                                    | $V_{GREF} = 3\text{ V}$  | -   | 4.4                | 7        | $\Omega$      |          |
|   |                                    | $V_{GREF} = 2.3\text{ V}$  | -   | 5.5                | 9        | $\Omega$      |          |
|   |                                    | $V_{GREF} = 1.5\text{ V}$  | -   | 67                 | 105      | $\Omega$      |          |
|   |                                    | $V_I = 0\text{ V}$ ; $I_O = 30\text{ mA}$ ; $V_{GREF} = 1.5\text{ V}$  | [2] | -                  | 9        | 15            | $\Omega$ |
|   |                                    | $V_I = 2.4\text{ V}$ ; $I_O = 15\text{ mA}$ ; $V_{GREF} = 4.5\text{ V}$  | [2] | -                  | 7        | 10            | $\Omega$ |
|   |                                    | $V_I = 2.4\text{ V}$ ; $I_O = 15\text{ mA}$ ; $V_{GREF} = 3\text{ V}$  | [2] | -                  | 58       | 80            | $\Omega$ |
| $V_I = 1.7\text{ V}$ ; $I_O = 15\text{ mA}$ ; $V_{GREF} = 2.3\text{ V}$ | [2]                                | -  | 50  | 70                 | $\Omega$ |               |          |

[1] All typical values are measured at  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

[2] Measured by the voltage drop between the Sn and the Dn terminals at the indicated current through the switch. ON-state resistance is determined by the lowest voltage of the two (Sn or Dn) terminals.

## 12. Dynamic characteristics

### 12.1 Dynamic characteristics for translator-type application

**Table 10. Dynamic characteristics**

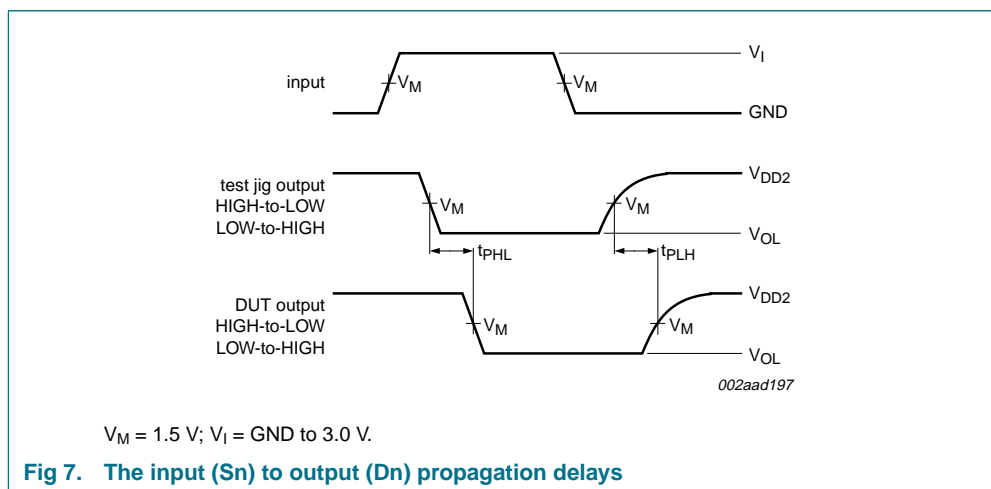
$T_{amb} = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ ;  $V_{ref} = 1.365\text{ V}$  to  $1.635\text{ V}$ ;  $V_{DD1} = 3.0\text{ V}$  to  $3.6\text{ V}$ ;  $V_{DD2} = 2.36\text{ V}$  to  $2.64\text{ V}$ ;  $GND = 0\text{ V}$ ;  $t_r = t_f \leq 3.0\text{ ns}$ ; unless otherwise specified. Refer to [Figure 9](#).

| Symbol    | Parameter                     | Conditions         | Min                        | Typ <sup>[1]</sup> | Max | Unit |
|-----------|-------------------------------|--------------------|----------------------------|--------------------|-----|------|
| $t_{PLH}$ | LOW-to-HIGH propagation delay | Sn to Dn; Dn to Sn | <a href="#">[2][3]</a> 0.5 | 1.5                | 5.5 | ns   |
| $t_{PHL}$ | HIGH-to-LOW propagation delay | Sn to Dn; Dn to Sn | <a href="#">[2][3]</a> 0.5 | 1.5                | 5.5 | ns   |

[1] All typical values are measured at  $V_{DD1} = 3.3\text{ V}$ ,  $V_{DD2} = 2.5\text{ V}$ ,  $V_{ref} = 1.5\text{ V}$  and  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

[2] Propagation delay is measured using [Figure 9](#) and is a difference measurement. It is not production tested and is guaranteed by ON-state resistance.

[3]  $C_{io(on)}$  maximum of 30 pF and  $C_{io(off)}$  maximum of 15 pF is guaranteed by design.



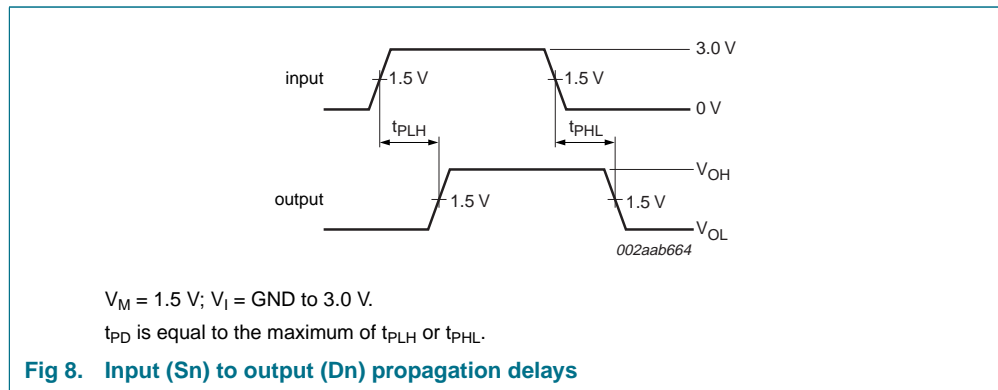
## 12.2 Dynamic characteristics for CBT-type application

**Table 11. Dynamic characteristics**

$T_{amb} = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ ;  $V_{GREF} = 5\text{ V} \pm 0.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $C_L = 50\text{ pF}$ ; unless otherwise specified. Refer to [Figure 10](#).

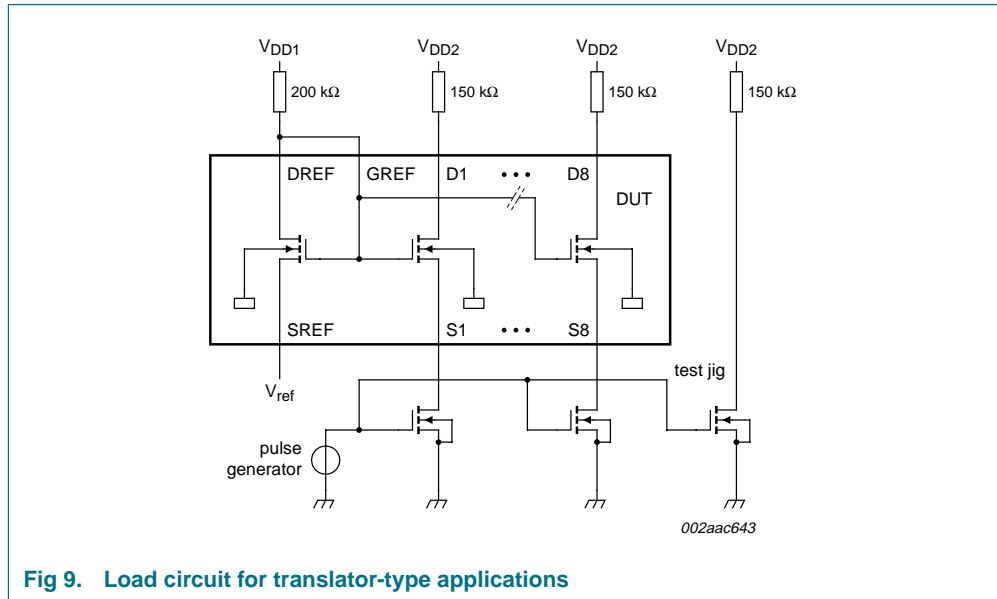
| Symbol   | Parameter         | Conditions | Min | Typ | Max | Unit |
|----------|-------------------|------------|-----|-----|-----|------|
| $t_{PD}$ | propagation delay | [1]        | -   | -   | 250 | ps   |

[1] This parameter is warranted by the ON-state resistance, but is not production tested. The propagation delay is based on the RC time constant of the typical ON-state resistance of the switch and a load capacitance of 50 pF, when driven by an ideal voltage source (zero output impedance).

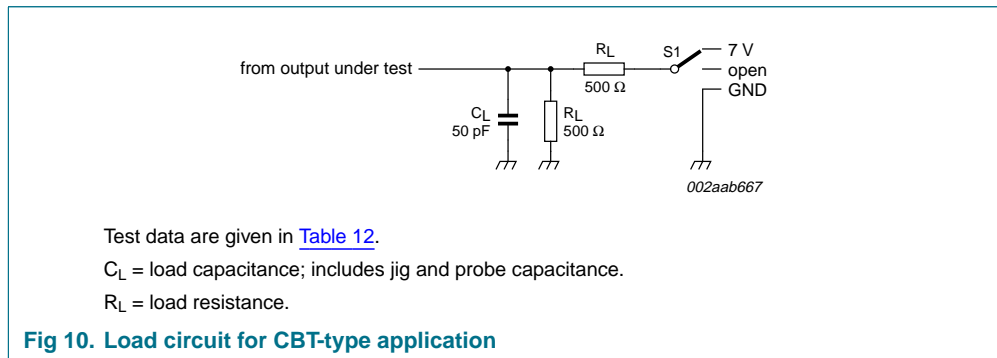


**Fig 8. Input (Sn) to output (Dn) propagation delays**

**13. Test information**



**Fig 9. Load circuit for translator-type applications**



**Fig 10. Load circuit for CBT-type application**

**Table 12. Test data**

| Test                  | Load  |              | Switch |
|-----------------------|-------|--------------|--------|
|                       | $C_L$ | $R_L$        |        |
| $t_{PD}$              | 50 pF | 500 $\Omega$ | open   |
| $t_{PLZ}$ , $t_{PZL}$ | 50 pF | 500 $\Omega$ | 7 V    |
| $t_{PHZ}$ , $t_{PZH}$ | 50 pF | 500 $\Omega$ | open   |

### 14. Package outline

TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1

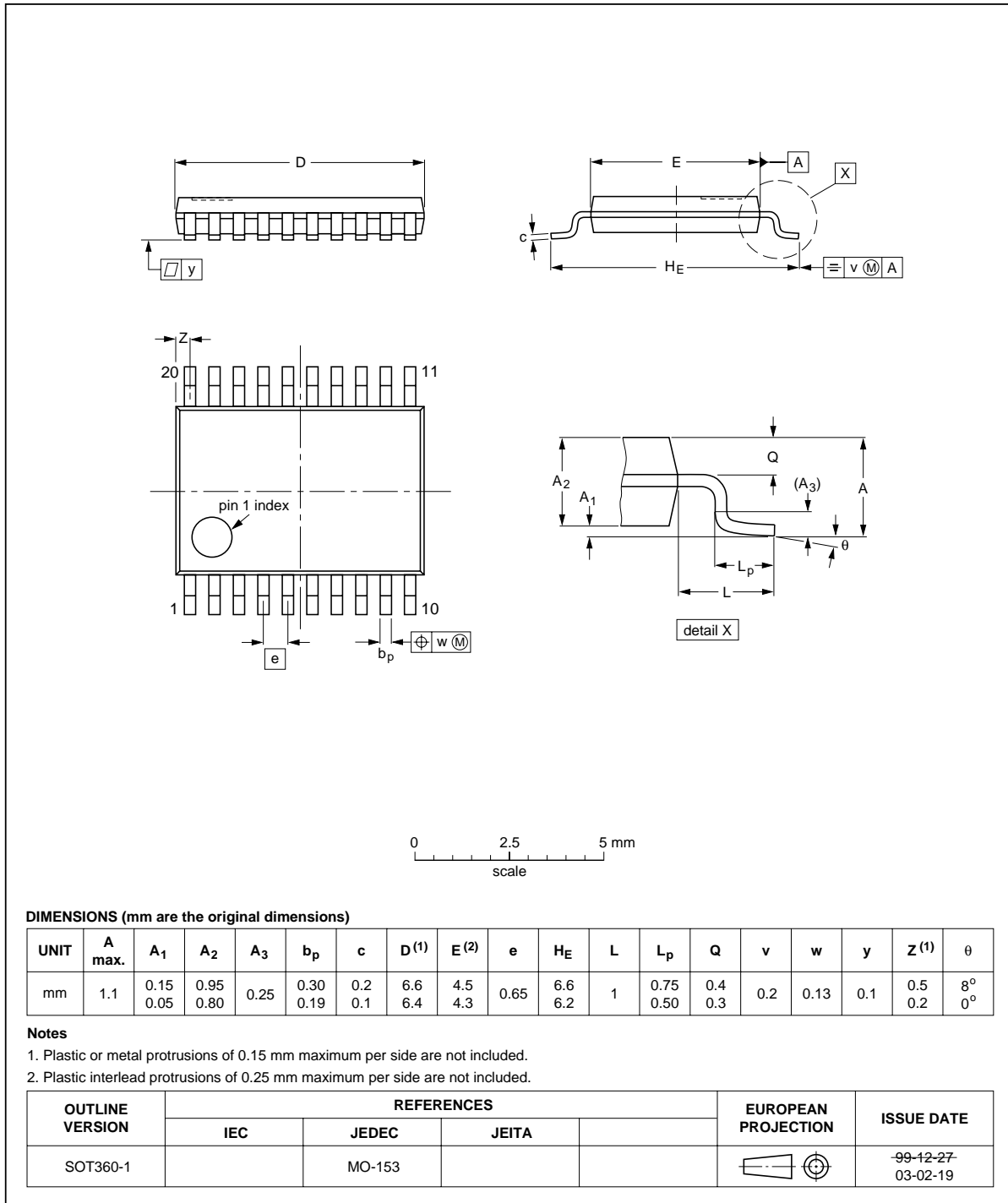


Fig 11. Package outline SOT360-1 (TSSOP20)

DHVQFN20: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 20 terminals; body 2.5 x 4.5 x 0.85 mm SOT764-1

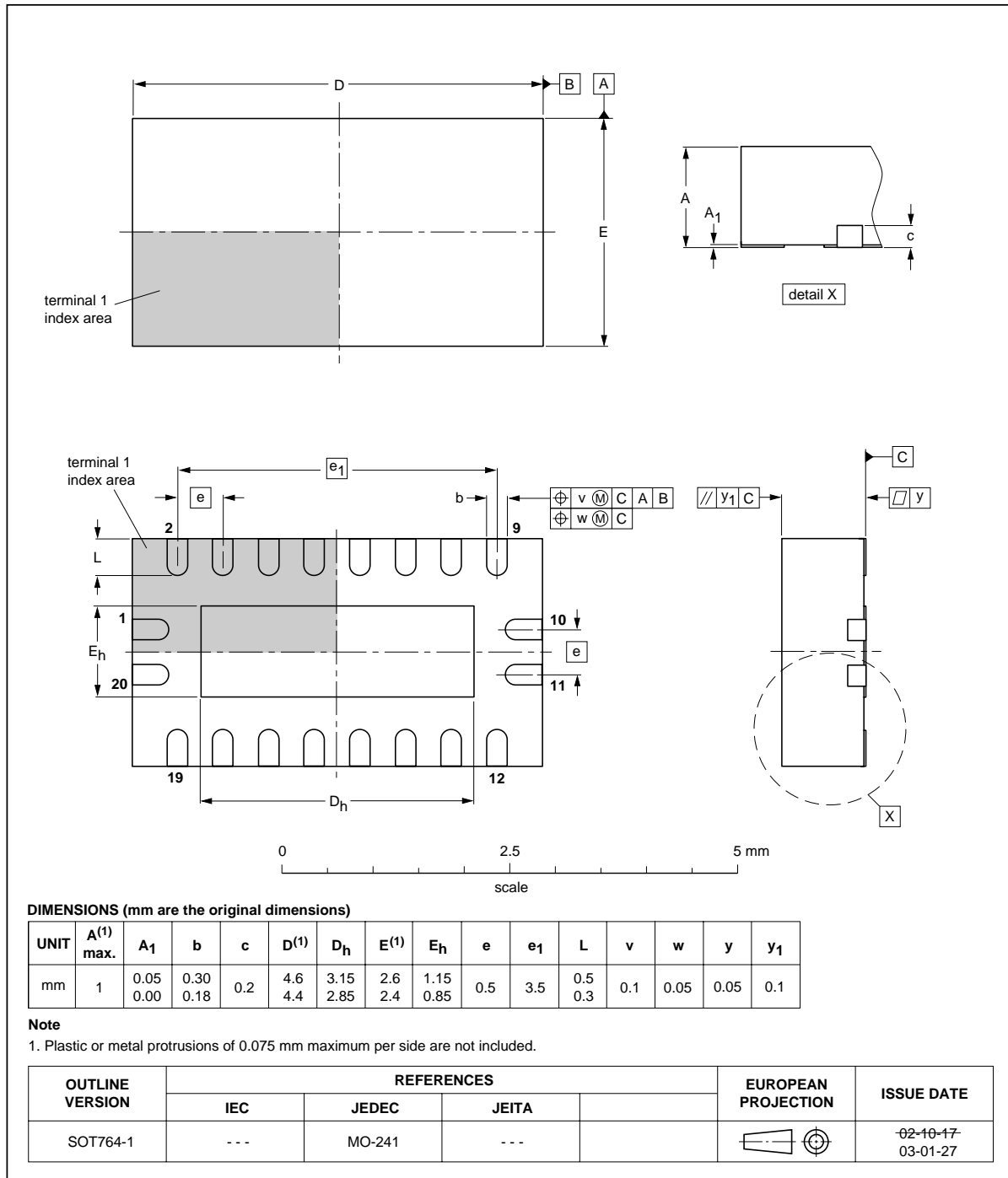


Fig 12. Package outline SOT764-1 (DHVQFN20)

## 15. Soldering

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

### 15.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

### 15.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus PbSn soldering

### 15.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

## 15.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 13](#)) than a PbSn process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 13](#) and [14](#)

**Table 13. SnPb eutectic process (from J-STD-020C)**

| Package thickness (mm) | Package reflow temperature (°C) |       |
|------------------------|---------------------------------|-------|
|                        | Volume (mm <sup>3</sup> )       |       |
|                        | < 350                           | ≥ 350 |
| < 2.5                  | 235                             | 220   |
| ≥ 2.5                  | 220                             | 220   |

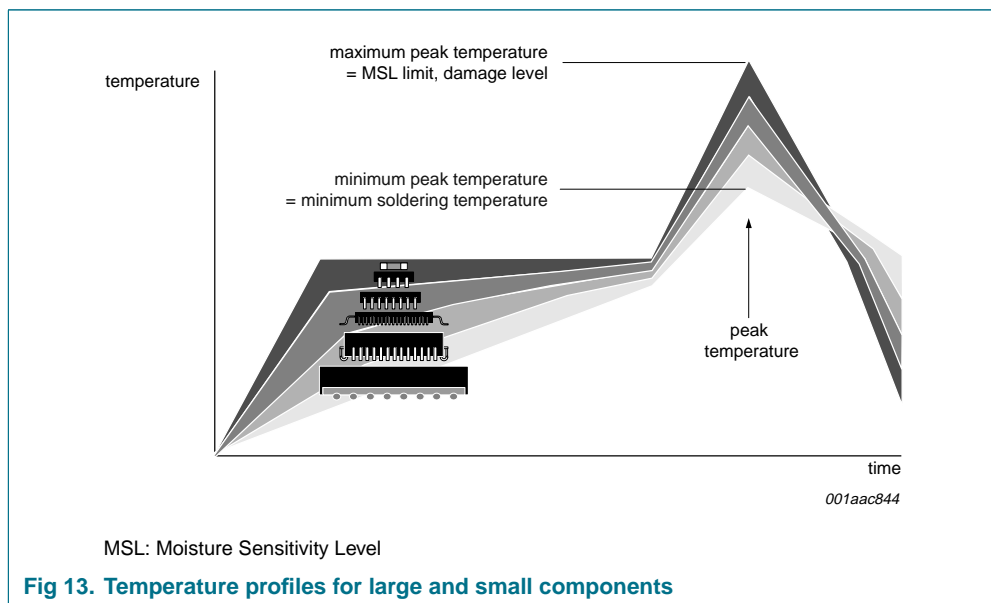
**Table 14. Lead-free process (from J-STD-020C)**

| Package thickness (mm) | Package reflow temperature (°C) |             |        |
|------------------------|---------------------------------|-------------|--------|
|                        | Volume (mm <sup>3</sup> )       |             |        |
|                        | < 350                           | 350 to 2000 | > 2000 |
| < 1.6                  | 260                             | 260         | 260    |
| 1.6 to 2.5             | 260                             | 250         | 245    |
| > 2.5                  | 250                             | 245         | 245    |

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 13](#).





For further information on temperature profiles, refer to Application Note AN10365 “Surface mount reflow soldering description”.

## 16. Abbreviations

**Table 15. Abbreviations**

| Acronym              | Description                                |
|----------------------|--|
| CDM                  | Charged Device Model                       |
| CMOS                 | Complementary Metal Oxide Semiconductor    |
| DUT                  | Device Under Test                          |
| ESD                  | ElectroStatic Discharge                    |
| GTL                  | Gunning Transceiver Logic                  |
| HBM                  | Human Body Model                           |
| I <sup>2</sup> C-bus | Inter-Integrated Circuit bus               |
| LVTTTL               | Low Voltage Transistor-Transistor Logic    |
| MM                   | Machine Model                              |
| NMOS                 | Negative-channel Metal Oxide Semiconductor |
| TTL                  | Transistor-Transistor Logic                |
| TVC                  | Transceiver Voltage Clamps                 |

## 17. Revision history

**Table 16. Revision history**

| Document ID | Release date | Data sheet status  | Change notice | Supersedes |
|-------------|--------------|--------------------|---------------|------------|
| GTL2003_1   | 20070727     | Product data sheet | -             | -          |

## 18. Legal information

### 18.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition  |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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